Trans-Pacific HDR Satellite Communications Experiment Phase-2 : Experimental Network and Demonstration Plan

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ABSTRACT

The trans-Pacific high data rate (TP-HDR) satellite communications experiment was proposed at the Japan-U.S. Cooperation in Space (JUCS) Program Workshop held in Hawaii in 1993 and remote high definition video post-production was demonstrated as the first phase trial. Following the first phase, the second phase experiment is currently prepared. This paper describes the experimental network configuration, application demonstration, and performance evaluation plan of the second phase experiment.

INTRODUCTION

The trans-Pacific high data rate (TP-HDR) satellite communications experiment was proposed at the Japan-U.S. Cooperation in Space (JUCS) Program Workshop held in Hawaii in 1993. The objectives for the experiment are to demonstrate the usefulness of satellite communications systems for constructing global high data rate (HDR) networks and its operability with actual applications. The remote high definition video (HDV) post-production was demonstrated as an application in the first phase trial[1]-[3]. ATM-based 45 Mbps trans-Pacific link was established with 2 hop satellite link through NASA/ACTS and Intelsat, and three terrestrial networks in California, Hawaii and Tokyo in the first phase. We could achieve almost error free ATM connection, and measured error statistics when the link quality degraded[4]. The remote HDV post-production trial was successfully demonstrated. Following the phase 1 experiment, phase 2 experiment was planned and it is currently under preparation. In the phase 2 experiments, the transmission rate through the trans-Pacific link will be upgraded to 155.52 Mbps and more technical trials will be carried out compared with the phase 1 which was concentrated the demonstration. Remote astronomy and digital library demonstration will also be done as application trials. This paper describes the experimental network configuration and project plan of TP-HDR experiment phase 2.

NETWORK CONFIGURATION

The experimental network is shown in figure 1. The Intelsat will be used to provide connection between Japan and the United States directly. CRL's Kashima Space Research Center (KSRC) and AT&T's Salt Creek earth station are the gateway stations in both sides of the satellite link. Domestic connections in both sides can be chosen from a few options.

In Japan, we will use NTT's N-STAR to connect application site and KSRC as the primary option. For this connection, transportable Ka-band earth station will be placed in the application site. The major specifications and the exterior of the transportable Ka-band earth station is shown in table 1 and fig.2, respectively. It has 1.8 mø dish and 150 Watts transmitter. Both of 155.52 Mbps and 45 Mbps modems and ATM switch are installed inside the container and baseband connection is available to application systems.

Alternative option is to utilize terrestrial Gigabit network so

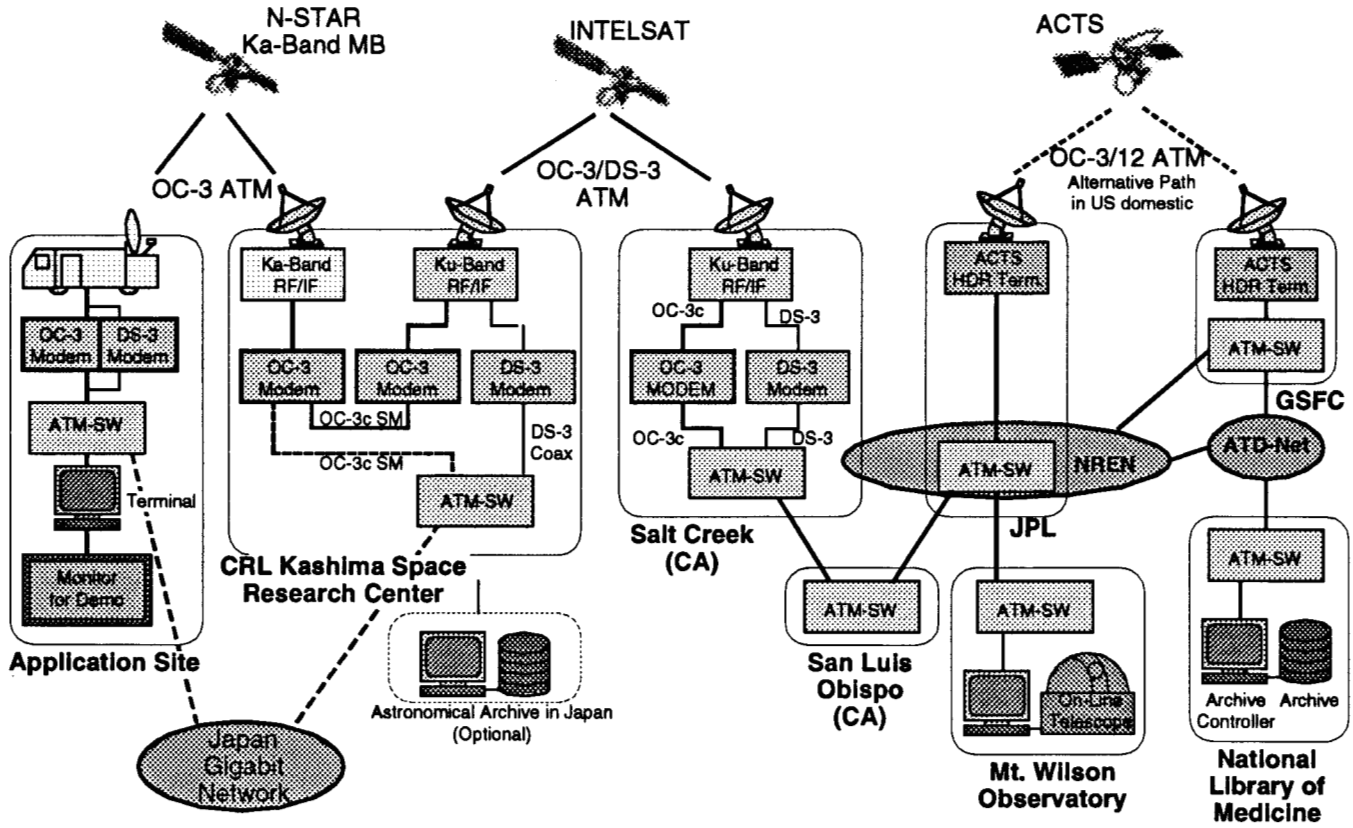

Fig.1 Experimental Network Configuration

Table1 Major Specifications of Transportable ES

Tx Freq :	28.4 ~ 30.3 GHz
Rx Freq :	18.6 ~ 20.1 GHz
Antenna :	1.8 mø
Tx Power :	150 W
IF Freq :	140 MHz
MODEM :	SDM-155 (8PSK, OC-3)
	SDM-9000 (OC-1, DS-3)
ATM-SW :	Newbridge 36150
	OC-3(SM), DS-3(Coax),
	DS-1(Coax)
Pwr Consm :	17 kVA (200V, 3ø)
Weight :	4.2 t

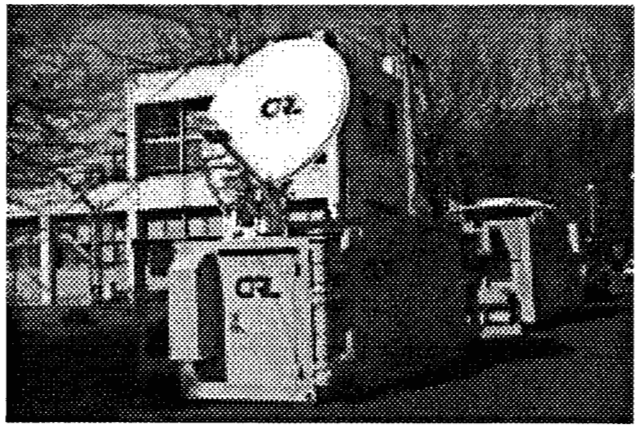

Fig.2 Exterior of Transportable ES

called Japan Gigabit Network (JGN) which is provided for research purposes by the Ministry of Posts and Telecommunications. In this case, we should consider the way to connect KSRC and application site to the nearest nodes of the Gigabit network.

In the United States, AT&T's Salt Creek earth station will be connected to NREN backbone via network operation center in San Luis Obispo. Most of the application sites for fundamental experiments and application demonstrations are linked through NREN. Jet Propulsion Laboratory (JPL) is the gateway to Mt. Wilson observatory. Schools participating remote astronomy demonstration will be connected by lower rate local access line. ATD net is bridging NREN and application sites in Washington D.C. / Maryland area such as Goddard Space Flight Center. The ACTS satellite link is a candidate as a backup link.

Application sites in both sides will be connected through these links at the transmission rate of up to 155.52 Mbps with TCP/

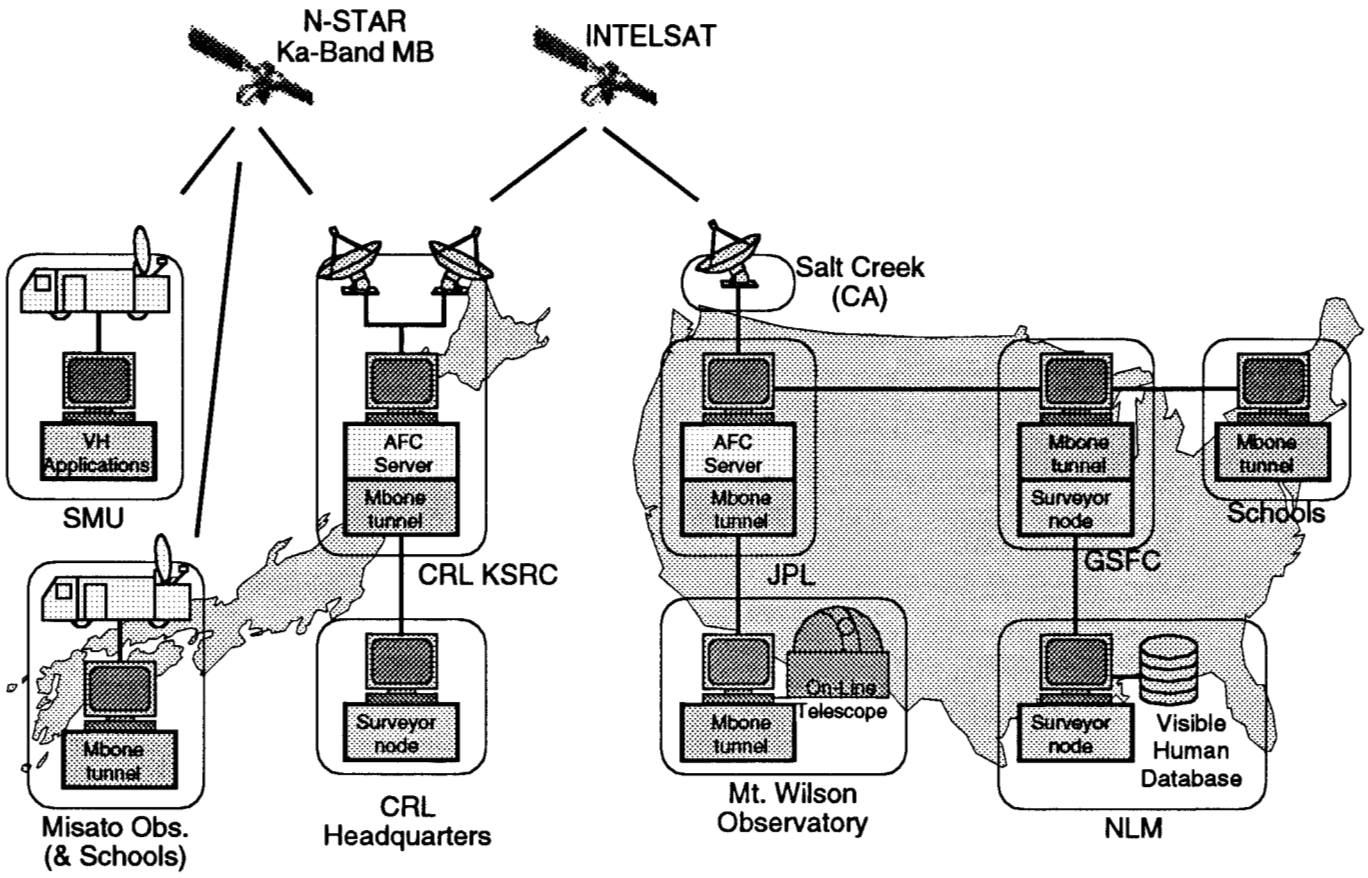

Fig.3 Functional Node Distribution

IP over ATM or ATM native protocols.

FUNDAMENTAL EXPERIMENTS

Before the applications demonstration, we carry out the fundamental experiments which was not carried out sufficiently in the phase 1. The ATM networking and ATM-based application was prefromed in the phase 1, and we add TCP/IP connection and internet applications will be demonstrated in the phase 2. Therefore, we plan to evaluate the performance of TCP/IP over the trans-Pacific link as well as ATM transmission performance. The functional node distribution in the network is shown in fig.3. Multicast capability, Andrew File System servers and Surveyor measurement equipment are implemented in this network for fundamental experiments.

ATM Performance Test

The experimental network employs ATM protocol in lower layer, the ATM transmission performance should be evaluated. Especially, in large scale network like NREN, traffic burst generated in AAL5 service class faces cell loss and cell delay. We plan to set ATM testers in several points in this network to measure cell loss and delay in conjunction with bit error rate and TCP/IP performance.

TCP/IP Performance Test

Since this experimental network consists of two hop satellite links and large scale terrestrial networks, TCP/IP performance between Japan and the United States is thought to be affected by various factors. Delay and bit errors by satellite links, and congestion in nodes of terrestrial networks degrade TCP/IP throughput. In order to avoid throughput degradation by delay of satellite links, TCP extension of RFC 1323 and / or RFC 2018 should be used. We would like to evaluate the performance improvement by these TCP extension protocols with various parameter sets.

We plan to install "netspec" and other software tools for the TCP/IP performance evaluation in workstations at several points. In addition, we will set up the Surveyor tool in Japan and join the Surveyor network in order to measure accurate TCP/IP performance.

Multicast Performance Test[5]

Multicast capability is useful to implement remote collaboration environment. Mbone is planned to be used for this experiment for audio and video distribution. We will gather prehop loss and delay, route i and other information by "mtrace" software tool.

Distributed File System Performance Test

Distributed file system is useful to share large amount of data among users in wide spread locations. We plan to install Andrew File System (AFS) to share astronomical data with unified hierarchical file structure among scientists in both countries. Because the experimental link will be shutdown occasionally, we are interested in that the functions and performance of AFS are maintained. Therefore, we will monitor the behavior of AFS using the "Andrew Benchmark" tool.

APPLICATION DEMONSTRATIONS

As the applications demonstration, the remote astronomical observation and digital library access are planned. Both of those applications are based on a huge database sharing technology and require large bandwidth networking worldwidely. With these applications, we will demonstrate the effectiveness of use of HDR satellite communications systems to deploy a broadband network globally.

Remote Astronomy Observation[5]

The remote astronomical observation is the idea to utilize time difference between Japan and the U.S., which means we can observe night sky in the U.S. staying in Japan in day time, for example. In addition, networking collaboration system such as teleconferencing and white board software will help to realize tele-education or distributed research environment.

As the information servers, Mt. Wilson observatory, GSFC and one of Japanese observatory will be connected. These sites will feed live or stored image of the universe including processed data obtained by Hubble Space Telescope. Several schools in the United States and Japan will participate to this experiment to demonstrate tele-education application. Scientists, teachers and students in these locations can retrieve live images and compare to stored images to learn the objects, for example. Remote collaboration systems based on multicast connection will be implemented in these locations, and they will be able to discuss for research or educational purposes.

Digital Library (Visible Human) Access

Visible human data retrieval / processing application is one of the digital library applications that we would like to demonstrate in this experiment. The Visible Human (VH) is the anatomical dataset contains 55 GB data (15 GB : male, 40 GB : female) stored in the National Library of Medicine (NLM). This dataset is shared by medical doctors worldwidely for interactive biomedical image segmentation, labeling, classification and indexing. Sapporo Medical University (SMU) in Hokkaido, Japan participate the VH project and developed a software tool to show sagital, longitudinal,coronal sections of a human body, and interactive segmentation. In addition, other medical research related applications such as remote microscope manipulation software via the internet, medical image retrieval from remote Laser Disk database with ATM native transmission scheme are also developed in SMU.

SMU will be connected to NLM via N-STAR / Intelsat satellite links and NREN, and these applications will be demonstrated. If the JGN connection from SMU to KSRC is available concurrently, the delay effect for these application will be compared in both routing situations.

CONCLUSIONS

We are now the finalizing stage of network design, and will start connection verification as soon as the link becomes available. We plan to start trans-Pacific link quality measurement and fundamental protocol test in July. The demonstrations will be done until the end of September, 1999. This experiment will show the effectiveness to use HDR satellite communications systems to deploy broadband networks to the whole globe, and operability for various kind of applications. In addition, the results of fundamental experiment will bring valuable experiences for the future networking in space.

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